Artist's rendering of Brilliant Pebbles.

Courtesy Missile Defense Agency

Space and Missile Defense

By DONALD R. BAUCOM

Since the dawn of the space age, developing space-based systems has never been a purely technological matter. The first orbital satellites raised questions on the legality of overflights and activities in space. The world community turned by habit to treaty negotiations and international law to resolve the implications of such issues.

Overflights were assumed away as the United States and the Soviet Union launched scientific satellites to mark the International Geophysical Year in 1957. De facto rights on overflight were established in October of that year when Sputnik went into orbit. Soon Washington and Moscow opened talks on restricting space-based military operations, with the United Nations providing the venue for creating a legal framework on the international governance of space.

With American prodding, the United Nations organized a Committee on the Peaceful Uses of Outer Space in late 1958, which became a major forum for developing international principles. The work of this committee, together with diplomatic efforts by the major nuclear powers, produced a number of agreements on military activities in space.

Lieutenant Colonel Donald R. Baucom, USAF (Ret.), is historian of the Missile Defense Agency and the author of *The Origins of SDI, 1944–1983*.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2003**	2. REPORT TYPE	3. DATES COVERED **00-00-2002 to 00-00-2003**
4. TITLE AND SUBTITLE **Space and Missile Defense**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **National Defense University,Institute for National Strategic Studies,260 Fifth Avenue SW Bg 64 Fort Lesley J. McNair,Washington,DC,20319**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

In August 1963, the United States, Soviet Union, and United Kingdom signed the Limited Test Ban Treaty in Moscow. This agreement, which eventually had over a hundred signatories, prohibited nuclear testing in space. Two months later, the United Nations adopted a resolution that banned nuclear weapons in space and in December 1963 passed a resolution establishing a set of general rules on the use of space. While this document included a requirement for "international consultations" before a nation took actions that might interfere with the peaceful use of space, it did not ban military systems. The terms of the resolution effectively allowed the United States and the Soviet Union to deploy military satellites. This result was not surprising: deployments had already become central to the space programs of the two superpowers.

The next major U.N. space-related agreement, the Outer Space Treaty of 1967, received unanimous approval from the General Assembly. Signed by 66 nations, it mustered a vote of 88–0 in the Senate. Its provisions did little more than consolidate the terms of the earlier resolutions and recast them in the form of a binding treaty. The superpowers remained free to deploy military satellites as long as they did not interfere with peaceful activities in space.

Signing Limited Test Ban Treaty.

AP / Wide World Photo

Space-Based Missiles

When the Senate ratified the Outer Space Treaty, the Pentagon had been pursuing missile defenses for two decades, starting with the discovery of German wartime plans for an intercontinental ballistic missile (ICBM) that could have reached New York by 1946. At the outset of the program, limitations in sensors, missile controls, and guidance systems required interceptors to be nuclear-tipped in order to destroy relatively small, high-speed targets presented by long-range missiles. The first American missile defense interceptor, the Nike-Zeus, was a large, ground-controlled projectile that carried a multimegaton warhead.

While the Nike-Zeus was in the initial stages of development, the Advanced Research Projects Agency (ARPA) was established as a response to the launch of Sputnik. Among its first efforts was Project Defender, the search for a defense against ballistic missiles. Previously, space-based missile defenses were considered impractical because of the on-orbit mass associated with a constellation of nuclear-tipped interceptors. However, when researchers gathered in 1960, that perception had begun to change. Their work indicated that it might become possible to develop an interceptor that could destroy targets by physically colliding with them. The energy released by such an impact would be six times that of exploding TNT equal to the mass of the interceptor. As one study indicated, this hit-to-kill (HTK) concept "removes the necessity of using a nuclear warhead and replaces it with a simple, cheap, lightweight mechanical device." That meant weight in orbit could be reduced by about two orders

the Advanced Research Projects Agency was established as a response to the launch of Sputnik

Marking SDI anniversary.

AP/Wide World Photo (Charles Tasnadi)

in magnitude. Boost-phase intercept was no longer mere fancy; it was a concept regarded as "sufficiently promising to warrant increased study."

Several of the concepts for space-based interceptors (SBIs) advanced in 1960 were capable of boost-phase kill and were collectively known as ballistic missile boost intercept (BAMBI). One of them was the space patrol active defense (SPAD). It included a 30-ton satellite with an infrared scanner to pick up boosters, a computer to calculate their tracks, and 140 interceptors weighing 300 pounds each. Fired from the host satellite, each interceptor would deploy a wire web with a radius of 15 to 50 feet containing many 1-gram pellets fixed along the radial wires. Although the pellets could damage ICBM nose cones, causing them to burn up on reentry, they were designed to attack vulnerable fuel tanks in the booster. Striking at velocities up to sixty thousand feet per second, they would inflict catastrophic damage. To ensure system effectiveness, 500 satellites would be orbited at an altitude of 250 miles above the earth.

Among the challenges of developing such a system was using infrared sensing devices to detect missile launches and guide interceptors to their targets. If the former seemed manageable, the latter did not. "Several magnitudes of improvement" were required for the second function. Other obstacles included achieving stability in satellites, dealing with countermeasures, reducing launch costs, and improving the reliability of space-based systems.

Technology in the early 1960s was incapable of reifying space-based concepts that emerged from Project Defender. Nevertheless, the project spawned a stream of research and development efforts that eventually fed into the Strategic Defense Initiative (SDI), launched in 1983.

Hit-to-Kill

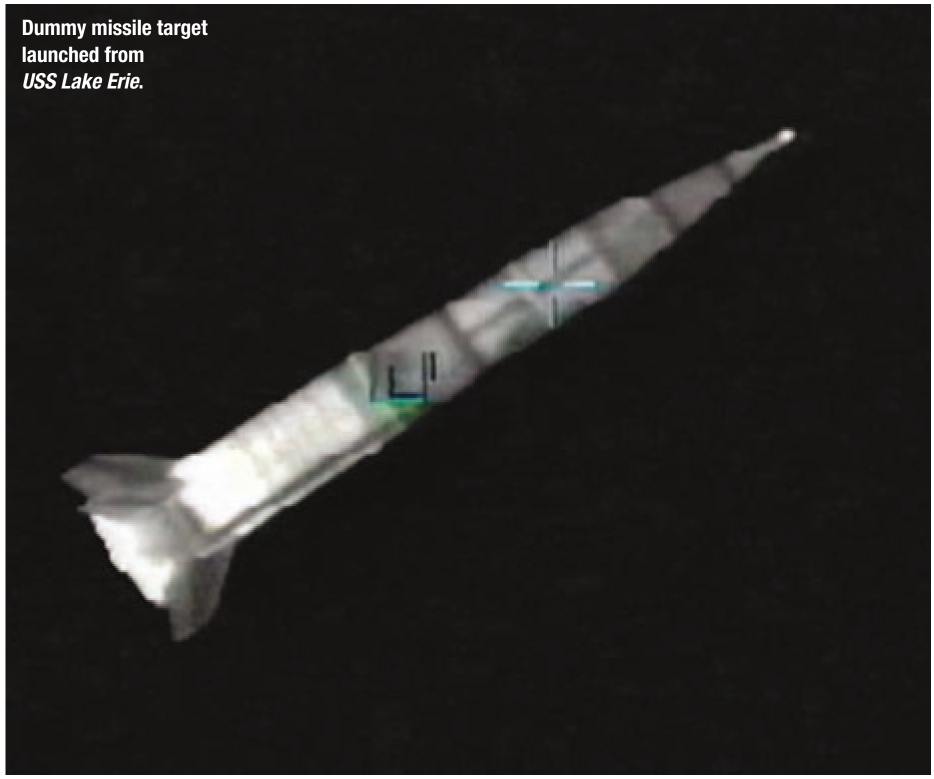
While Project Defender was examining missile defense concepts, the Vought Corporation began focusing on the homing interceptor-terminal (HIT). Sponsored by ARPA and the Army, this program aimed at producing "a small and lightweight, spin stabilized, optically guided interceptor that achieves hypervelocity direct impact kill of reentry vehicles in the exoatmosphere." The effort continued into the 1970s when HIT technology was applied to the miniature system project (MSP), the development of an anti-satellite (ASAT) capability for the Air Force. MSP led to the miniature homing vehicle (MHV), which was virtually identical to earlier HIT vehicles. MHV would serve as the kill vehicle in the ASAT system to be launched from the F–15 fighter. The program culminated in 1985 when MHV destroyed an orbiting satellite.

As HIT technology was transitioned into the Air Force ASAT program, the Army Safeguard missile defense system began a short operational life span. Safeguard was a layered system with two types of nuclear-tipped interceptors. The long-range Spartan, an outgrowth of the Nike-Zeus program, was designed to attack incoming warheads at the edge of the atmosphere. Warheads that got past Spartan would be destroyed inside the atmosphere by the high-speed, short-range Sprint.

Safeguard, which became operational in 1975, had a major disadvantage; the detonation of the nuclear warheads on Spartan and Sprint would blind its radars. It was further limited

by the ABM Treaty and the 1974 protocol to that agreement, restricting signatories to a single missile defense site with a hundred interceptors. Moreover, it prohibited deployment, if not development, of space-based missile defense systems. Since Safeguard could only defend ICBM silos near Grand Forks in North Dakota, and could itself be overwhelmed by a Soviet attack, Congress acted to terminate the system in 1976.

With the end of Safeguard, the Army focused missile defense on exoatmospheric hit-to-kill interceptors. Work on this program culminated in 1984, when a homing overlay experiment (HOE) test vehicle collided with an unarmed reentry vehicle over the Pacific Ocean, verifying the principles behind exoatmospheric HTK interceptors. HOE success pointed toward a revolution in interceptor design; nuclear warheads were no longer required to achieve a reasonably high kill-probability. The accomplishments of this program, along with earlier work on HIT, provided a strong technology base for the space-based interceptor programs pursued under SDI.



Dummy missile target launched from *USS Lake Erie.*

AP / Wide World Photo

The Role of Interceptors

President Ronald Reagan announced the decision to begin the SDI program in 1983. After a year of study and two and a half years of research and development, the Secretary of Defense approved the acquisition of the phase I architecture for the strategic defense system (SDS).

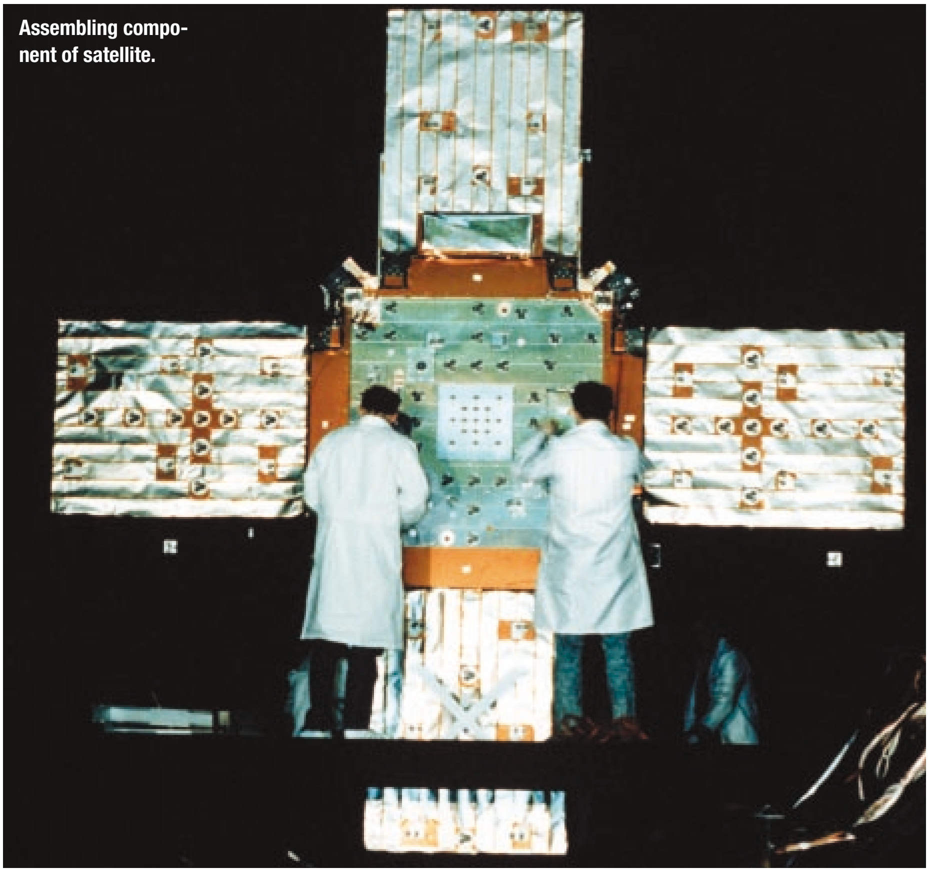
The principal weapon system in the SDS architecture was a constellation of several hundred SBIs. Similar to SPAD, it included large garage satellites with up to ten interceptors and two space-based infrared sensor systems. The boost surveillance and tracking system (BSTS), an Air Force program absorbed under SDI, would detect launches and track missiles throughout booster burn. The space surveillance and tracking system (SSTS) would track buses and then follow warheads once they separated from the buses.

The SDS phase I architecture had two major deficiencies: it was too costly and space-based assets, especially SBI, were vulnerable to Soviet ASAT systems. To overcome these problems, the SDI Organization (SDIO) replaced SBI with Brilliant Pebbles (BP). Since each interceptor had a sensor, on-board computer, and communications capability, it could operate autonomously without the large supporting satellites of SBI. Furthermore, BP interceptors would be mass produced, using off-the-shelf components that were largely commercial grade, making them relatively inexpensive. Moreover, replacing SBI with Brilliant Pebbles meant that instead of dealing with only a few hundred large, lucrative targets (SBI satellites containing multiple interceptors), Soviet ASAT systems would have to find, attack, and destroy thousands of small, inexpensive interceptors. Attacking these interceptors with ASATs was not cost-effective.

the Cold War ended as Brilliant Pebbles was being integrated into the strategic defense system

Because of on-board sensors, Brilliant Pebbles undercut requirements for BSTS and SSTS when it replaced SBI in 1990 and became the principal weapons system in a modified SDS phase I architecture. Since BSTS was originally taken from the Air Force to be part of SDI, and since the service still required an early warning and tracking capability, BSTS and SSTS were turned over to the Air Force and evolved into the current space-based infrared system program.

The Cold War ended as Brilliant Pebbles was being integrated into the strategic defense system architecture. A subsequent review advocated a new focus for SDI—limited missile attacks. In the new world order, it would no longer be necessary to defend against a massive Soviet ICBM attack. The most likely threat against the American homeland would be an unauthorized or accidental attack by one or two hundred Soviet warheads. Another was the proliferation of missile technology and weapons of mass destruction, which made it increasingly important to protect deployed U.S. forces and allied populations and forces from shorter-range missiles.



Assembling component of satellite.

The central element in the architecture would be a thin constellation of several hundred BP interceptors, providing an overarching upper tier to complement both deployed theater missile defenses and a limited national missile defense system. As such, Brilliant Pebbles became the key integrating element of a concept known as global protection against limited strikes (GPALS).

An America-led coalition was fighting a war against Iraq in less than a year. In the midst of that conflict, which featured the first operational engagements between ballistic missiles and missile defenses, the President announced that GPALS would be the architecture for SDI. Following the Gulf War, Congress passed the Missile Defense Act of 1991. This law appeared to support the expeditious deployment of the GPALS system, including Brilliant Pebbles. But it was a compromise between Republican advocates of missile defense and Democratic defenders of the ABM Treaty. In effect, the law gave half a loaf to treaty supporters and half to those who considered rapid deployment of missile defenses to be an urgent national priority—and neither side was fully satisfied.

After it interpreted the Missile Defense Act, DOD pursued a vigorous GPALS program that included substantial funding for the space-based BP system. This provoked a strong reaction from Democrats, who considered Brilliant Pebbles a threat to the ABM Treaty and beyond the pale of the law. When the Democrats gained control of Congress in 1992, they passed legislation that severely reduced spending on Brilliant Pebbles and prohibited including it in GPALS architecture, thereby fracturing an integrated global missile defense concept into separate components for national and theater missile defense.

Post-Cold War Realities

Bifurcation of missile defense, along with elimination of space-based interceptors, became the basic approach to missile defense under President Clinton. A major reason for this tack was the commitment of his administration to the ABM Treaty.

Under Reagan, and to a lesser extent under Bush, the United States attempted to use arms control negotiations to transition from offense-based nuclear deterrence to relying increasingly on strategic defenses. The ultimate goal was eliminating strategic nuclear weapons.

On the other hand, the Clinton administration considered arms control at least as important to guaranteeing the nuclear peace as strategic weapons. According to the head of the Arms Control and Disarmament Agency (ACDA), administration policy sought "to protect us first and foremost through arms control. . . ."[1] Under that position, it followed that strengthening the ABM Treaty enhanced national security.

In line with this view of arms control, ACDA denounced the interpretation by the previous administration of the ABM Treaty, which would have allowed development and perhaps deployment of space-based interceptors. Moreover, since space-based systems were not compatible with efforts to strengthen the treaty, it is not surprising that the Secretary of Defense removed Brilliant Pebbles from the demonstration-validation phase of the acquisition process and reduced it to a technology base program. By the end of 1993, the Ballistic Missile Defense Organization (BMDO), formerly SDIO, was forced to completely cancel the eviscerated program. Paradoxically, the greatest triumph of Brilliant Pebbles came after the death of the program in a joint BMDO–National Aeronautics and Space Administration (NASA) mission.

By January 1992 it had become apparent to SDIO that the agency would not be allowed to demonstrate the effectiveness of the technologies developed under Brilliant Pebbles. Since NASA had earlier approached DOD about the possibility of using SDI-developed technologies in its own program, SDIO agreed to use BP com-

ponents in a space probe known as Clementine. The mission called for the probe to orbit the moon for over two months and then depart the cislunar region for a rendezvous with the asteroid Geographos.

The probe was launched in early 1994 and completed the lunar portion of its mission. But while maneuvering for its flight to Geographos, a computer failure caused an extended burn of the altitude control system, depleting fuel and leaving the vehicle incapable of completing the second part of the mission. Nevertheless, Clementine served as a viable test in which 23 missile defense technologies performed successfully, including many derived directly from Brilliant Pebbles.

Clementine was the high water mark in space-based missile defenses. During the remaining years of the Clinton administration, space-based missile defense programs were largely limited to preparations for a far-term test of a high-power, space-based laser and the development of sensors that could cue ground-, sea-, and air-based missile defense systems.

George W. Bush assumed the presidency determined to deploy effective missile defenses in the shortest possible time. In support of this goal, the Secretary of Defense reorganized BMDO and renamed it the Missile Defense Agency (MDA) to prepare a set of options to reorient the missile defense program. These options were not to exclude ideas that conflicted with the ABM Treaty; they would be judged strictly on their technical merit. Furthermore, to end the bifurcation of missile defense into theater and national systems, a division that seemingly pitted U.S. interests against other nations, MDA would plan an integrated, layered defense to protect both America and its allies against ballistic missiles of all ranges.

The system that emerged from this restructuring divides the missile defense mission in three segments: boost, mid-course, and terminal—the major phases of ballistic missile flight. In theory, each segment could incorporate land-, sea-, air-, and space-based elements in the future. Moreover, all three segments will be integrated into a single ballistic missile defense system (BMDS) through both battle management and command and control systems.

To ensure the best technical and operational options in developing BMDS, Bush withdrew the United States from the ABM Treaty. Now, instead of designing a system to minimize violations of the treaty and then negotiating changes to preserve the agreement (the approach of the previous administration), MDA is drawing on the potential of all systems based on land, at sea, and in the air and space.

to ensure the best technical and operational options, Bush withdrew from the ABM Treaty

Although withdrawal from the ABM Treaty ended the legal strictures on developing space-based missile defense systems, it did not assure that such systems would rebound to the position accorded to them in the SDI program. Indeed, the emphasis of the present administration on early deployment of the most effective defenses possible means that the immediate focus in the program must be on ground-based systems, mid-course and terminal, since work on these systems has been steadily sustained by four Presidents. Thus the first operational system based on work that flowed from the SDI program will be the Patriot Advanced Capability-3 terminal system, which is currently being operationalized. This will be followed by the ground-based midcourse system, which should provide a limited defensive capability in the form of an Alaskan test bed system, scheduled to be operational in late 2004 or early 2005.

Under these conditions, space-based systems have been put on the back burner. The space-based laser program, which included a 2012 space-based experiment under the last administration, has now become a technology program focused on projects related to low power laser applications (tracking, imaging, and weapon guidance) and to high-power technologies that might feed into a future space-based laser project. And work on space-based HTK interceptors is included under a broader research and development project for kinetic energy boost phase interceptors.

Although the concept of space-based missile defenses using HTK interceptors emerged in 1960 from Project Defender, two decades of low-level efforts were required to bring this concept to fruition in the BP interceptor that was integrated in SDS phase I architecture. The technologies developed for Brilliant Pebbles were successfully demonstrated in the Clementine probe after the Clinton administration killed the former program. Thus, in a sense, Clementine was the climax of space-based missile defenses in the United States.

Space-based missile defenses have not achieved a comeback under the Bush administration despite the U.S. withdrawal from the ABM Treaty. Given the potential of space-based weapons as boost-phase missile killers, it seems unlikely that BAMBI-like concepts will completely lose their luster. Rather, they are likely to wait in the wings until better technologies and a new strategic setting call them back to center stage. JFQ

NOTE

[1] John D. Holum, "Remarks to a Conference Cosponsored by the Center for National Security Law and the ABA Standing Committee on Law and National Security," June 10, 1994.